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(54) Composite weld gun and method of making same.

(57) Structural elements of weld guns are made of composites for strength, low weight and long life. Anisotropic strength structures are fabricated by making a hollow form (30) and applying layers of carbon fabric (42,46) and unidirectional carbon fibres (44) which are aligned with the forces developed within the structure to withstand shear, tension and compression. A tough abrasion resistant fabric (48) such as an aramid fabric is applied as a protective covering. A resin binder unites the composite structure.

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COMPOSITE WELD GUN AND METHOD OF MAKING SAME

This invention relates to a composite weld gun and a method of making such a gun.

Resistance welding or spot welding is commonly applied to the assembly of automotive bodies and other products. The weld guns are often large to accommodate large sheets of steel requiring welds far from a convenient access location. These weld guns are generally held and manipulated by robots or held by hoists and manually manipulated. Traditionally the weld guns are made of strong metal structural elements to withstand the welding forces that must be applied to the weld electrodes. Consequently the weld guns may have very large mass which is difficult for a robot or other machine to manage with consistent positioning accuracy over an extended period of time due to wear in the robot wrist, for example. The heavy weld guns tend to have lifetimes limited by fatigue.

There have been some attempts to make light weight weld guns from composite materials which are strong but not as heavy as the traditional metal structures. Generally such structures have been formed by packing resin impregnated fibres or fabrics into a mould with random fibre orientation and curing the resin to obtain an isotropic product, that is a product which has no preferential load direction to withstand stress. Such devices have achieved light weight and dimensional stability but have exhibited short lives. Further, in order to fabricate such a device an expensive mould must be made.

Other known arrangements are shown in US-A-4,550,236; US-A-3,523,172; and US-A-3,021,417.

It is therefore an object of the invention to provide a composite weld gun having long life as well as high strength and light weight. It is another object to provide a method of making such a composite weld gun. It is a further object to provide a method of making such a weld gun without a mould.

To this end, a weld gun in accordance with the present invention, and a method of manufacture thereof, are characterised by the features specified in the characterising portions of Claims 1 and 5 respectively.

The invention is carried out by a weld gun having at least one structural element having high strength and light weight, said structural element comprising: a hollow form, and a composite jacket on said hollow core comprising at least one layer of high strength carbon fabric, unidirectional high strength carbon fibres in areas of tension or compression, an abrasion resistant outer fabric over the carbon covering, and a resin for binding the composite, whereby the structural element has both high strength and low weight as well as durability.

The invention is also carried out by the method of making a weld gun having at least a composite structural element, weld electrodes and an actuator, comprising the steps of: forming a form having the essential shape of the structural element, wrapping the form with a carbon fabric with the fabric direction at an angle to withstand shear forces in the structural element, applying unidirectional carbon fibre to regions of the structural element to withstand tension and compression forces in the structural element, applying a protective fabric over the carbon fabric and fibres, impregnating the fabrics and the fibres with resin, curing the resin to form the structural element, and assembling the weld electrodes and actuator to the structural element.

The present invention will now be described, by way of example, with reference to the following description taken in conjunction with the accompanying drawings wherein like references refer to like parts and wherein:-

Figure 1 is a perspective view of a weld gun according to the invention;

Figure 2 is a cross section view of the weld gun taken along line 2 - 2 of Figure 1;

Figure 3 is a side view of a form for making the weld gun of Figure 1;

Figures 4a and 4b are views of mounting brackets and end fittings for attachment to the form of Figure 3;

Figures 5 and 6 are views of the weld gun during different steps of fabrication to illustrate the process of making the gun; and

Figure 7 is a broken away view of a portion of the gun showing the application of layers of fabric to the form, according to the invention.

The ensuing description is primarily directed to a weld gun having a composite frame supporting weld electrodes and an actuator and the method of making the composite frame; however the invention is equally applicable to weld guns having other structural parts such as articulated jaws which are made of composites. In every case the weld guns have specific properties including high strength and stiffness which meets the requirements for tip deflection, torsional misalignment, and flexural stress and also are resistant to heat and humidity, impact and abrasion, and corrosion. The description is also directed to a very large weld gun for robot or other machine usage but smaller manually controlled weld guns also benefit from the principles of the invention. In each case the advantages to be gained are not only light weight but also low initial cost, long life and, in some cases, the elimination of expensive support equipment by reducing the

number of weld guns needed for a job.

Figure 1 shows a weld gun having a U-shaped frame 10 having a base section 12 and a pair of parallel arms 14 and 16 extending from the base. The lower arm 14 carries an electrode 18 while the upper arm 16 supports a direct acting cylinder or actuator 20 which carries an upper weld electrode 22 in alignment w ith the lower electrode 18. The frame 10 is hollow and contains coolant hoses 24 and an electrical cable 26, shown in section in Figure 2. A mounting bracket 28 secured to the side of the upper arm 16 provide an attachment point for coupling to a robot or hoist. In use the frame 10 must limit deflection of the electrodes 18, 22 when welding force is applied, and prevent torsion of the arms 14, 16 to maintain alignment of the electrodes 18, 22. The reach of the weld gun as established by the arm length must be large enough to span large sheets of material. The arms 14, 16 may be, for example, 91.4cm (36 inches) long or even greater than 127cm (50 inches) long, while the distance between the arms is on the order of 45.7cm or 61cm (18 or 24 inches).

The frame 10 is fabricated of non-magnetic material and is based on a form or core 30. The requirements of the form or core 30 are that it provide a carrier for applying the composite material and that the resultant frame 10 or other element be non-magnetic and be hollow to accommodate hoses 24 and cables 26. A hollow aluminium form serves this purpose but contributes little to the structural strength of the frame. Stainless steel forms are also used and these do contribute to the structural strength. Other forms may be used such as a polymer foam which is melted or dissolved after the composite structure is formed to leave a hollow within the composite.

As an example, a hollow aluminium form or core 30 (Figure 3) is formed by welding together plates shaped to approximate the desired shape of the frame 10 or by bending aluminium tubing on a mandrel to the desired shape. The mounting bracket 28 (Figure 4a) and end brackets 32 (Figure 4b) are formed of aluminium and welded to the form 30. The end brackets 32 have protruding box sections 34 which are inserted into the hollow ends of the form 30. As indicated generally at Figure 5 composite material 36 is applied to the outer surface of the aluminium form and then cured to complete the frame 10. Finally, as shown in Figure 6, the hoses 24 and cable 26 are inserted into the frame 10 and the actuator 20 and electrode 22 are secured to the end bracket 32 on the upper arm 16 and the electrode 18 is secured to the end bracket on the lower arm 14.

The procedure and materials for the composite material 36 are selected to provide the necessary strength and endurance for the weld gun. By using combinations of fibre types and orientations, properties of the structure can be tailored to meet specifications. Fabrics and unidirectional fibres are used. A critical design principle is that the fibre and fabric direction provides anisotropic strength and must be applied to the gun structure in directions to withstand the forces developed in the weld gun. A high strength carbon fibre is one preferred material and is referred to here as carbon. The high strength carbon has a tensile modulus of 207 x 10^6 to 241 x 10^6 kPa (30 to 35 million psi) and has a reasonably low cost in contrast to graphite which has a higher modulus and a higher cost. Other fibres are also used. Before application to the form 30, they are impregnated with a resin. Epoxy has been proven to be a good choice for the resin, although a polyester or vinylester resin may be used. The fabrics are spiral-wrapped on the form 30 in the manner of surgical bandages while the unidirectional fibre or tape is generally laid in the direction of a tensile or compressive force. This arrangement is illustrated in Figure 7.

First, a layer of plain weave glass fibre fabric 40 of a minimum of 203.4gm/m^2 (6 oz./square yard) areal weight is wrapped directly on the form 30 to separate the carbon fabric from the aluminium structure and prevent potential galvanic corrosion activity. The glass fabric is oriented at 45 degrees to allow it to carry shear loads in the vertical flats of the structure.

Next, three layers of carbon material are applied. One layer of carbon fabric 42 is laid over the glass fibre fabric 40 and will represent a minimum of 1.02mm (0.040 inch) thick consolidated composite. The 45 degree orientation is critical for carrying shear loads of the beam vertical flats under tip deflection conditions and for giving torsional stiffness to the gun structure. Then an unidirectional layer of carbon fibre tape 44 of a thickness determined by tip deflection analysis, say 3.05mm (0.120 inch), is applied along both the tension and compression faces 45 (Figure 1) of the U-shaped form 30. This laminate will provide stiffness and strength in the structure under tip deflection conditions. Depending on tip deflection requirements, local build-up of unidirectional material in the highly stressed radii of the structure may also be desirable. A second layer of carbon fabric 46, a minimum of 1.02mm (0.040 inch) thick, is applied at 45 degrees to encapsulate the unidirectional fibre and again to provide shear strength in the arms 14,16 and to control torsional deflection. A final layer 48 of an abrasion resistant, impact resistant and tough material provides a skin over the frame 10. An aramid fabric such as "Kevlar" (trademark) at least 1.02mm (0.040 inch) thick is applied at 45 degrees over the second layer of carbon fabric 46. While this will contribute to strength, its primary purpose

is to protect the other fibers from damage by sheet metal edges and general impact.

The several layers are compacted onto the core 30 by the technique of vacuum bagging as described in "Handbook of Composites", Lubin, 1982, pp 368 - 378, which is incorporated herein by reference. The uncured composite assembly is covered by a release film, a porous bleeder/breather blanket, and a bagging film which is sealed to form an air tight bag and then the air is evacuated. The ambient air pressure then compresses the frame 10 to remove any air pockets in the composite and compact the composite material 36 against the form 30. The assembly is cured at a temperature required by the particular resin used to impregnate the fabric and fibres. Typically the cure temperature is 121 to 177 degrees C (250 to 350 degrees F) and the cure is completed in 2 or 3 hours.

A composite weld gun frame like that of Figure 1 having a 2.54mm (0.1 inch) thick aluminium form 30, arms 91.4cm (36 inches) long spaced 45.7cm (18 inches) apart, having a section as in Figure 2 of about 7.62 by 12.7cm (3 by 5 inches) and covered in accordance with the above described process weighed 13.15kg (29 pounds). This was made as a replacement for a copper-beryllium frame weighing 90.72kg (200 pounds). Both weld guns meet the same specifications. The composite weld gun is not only stronger and lighter but has a much longer life. The life of the copper-beryllium weld gun is limited by fatigue. The composite weld gun is designed with an ultimate strength ten times the applied loads so that fatigue does not limit the life of the weld gun. The light weld gun reduces wear on robots and allows smaller robots to be used or allows larger weld guns to be handled by robots. A weld gun having a long reach can do the job of two smaller weld guns thereby reducing the number of weld guns and the number of robots needed.

Claims

1. A weld gun having at least one structural element (10) that is adapted to support a welding electrode (18,22), the structural element comprising a hollow form (30); characterised by a composite jacket (36) on the hollow form comprising at least one layer of carbon fabric (42,46), unidirectional carbon fibres (44) in areas of tension or compression, an abrasion resistant outer fabric (48) over the carbon covering, and a resin for binding the composite

2. A weld gun as claimed in Claim 1, wherein the hollow form (30) is metallic, and wherein the composite jacket (36) comprises a layer of electrical insulating fabric (40) adjacent the hollow form with the fabric (42, 46) and the fibres (44) over the insulating layer and being oriented in directions to withstand forces applied to the structural element (10).

3. A weld gun as claimed in Claim 2, in which the structural element (10) is U-shaped and defines a base member (12) and generally parallel arm members (14,16) supporting the welding electrode (18,22); wherein the hollow form (30) is U-shaped and has surfaces (45) subject to tension and compression when under load; wherein the insulating layer (40) is of fibreglass fabric; wherein the carbon fabric layer comprises first (42) and second layers (46); and wherein the fibres (44) are between the first and second layers and over the surfaces subject to tension and compression for bearing tensile and compressive forces.

4. A weld gun as claimed in claim 3, wherein the layers of fibreglass (40) and carbon fabric (42,46) are arranged with their fibres running diagonally with respect to the underlying form (30) members.

5. The method of making a weld gun having at least a composite structural element (10), weld electrodes (18,22) and an actuator (20), comprising the step of forming a form (30) having the essential shape of the structural element; characterised by the steps of wrapping the form (30) with a carbon fabric (42,46) with the fabric direction at an angle to withstand shear forces in the structural element (10); applying unidirectional carbon fibre (44) to regions (45) of the structural element to withstand tension and compression forces in the structural element; applying a protective fabric (48) over the carbon fabric and fibres; impregnating the fabrics and the fibres with resin; curing the resin to form the structural element; and assembling the weld electrodes and actuator to the structural element.

6. A method as claimed in Claim 5, in which the form (30) is metallic, comprising the additional step of wrapping the form with fiberglass fabric (40); wherein the carbon fabric comprises a first layer (42) of fabric over the fibreglass fabric, and a second layer (46) over the unidirectional carbon fibre (44).

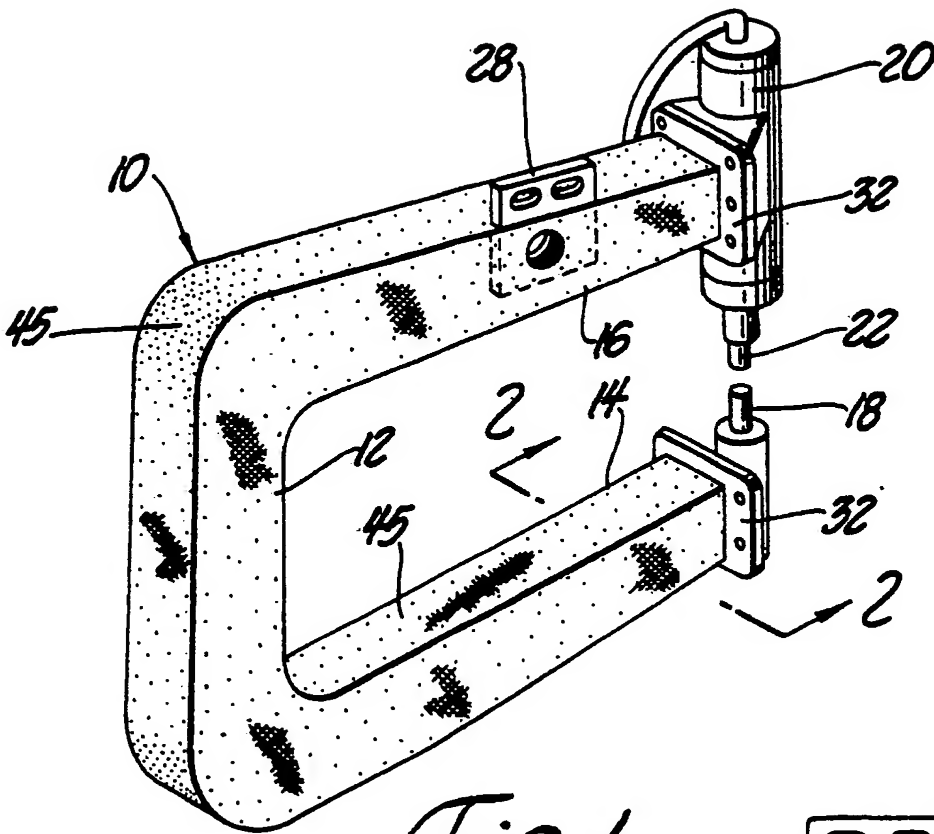

Fig.1

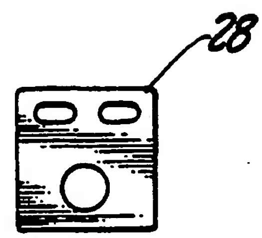

Fig.4a

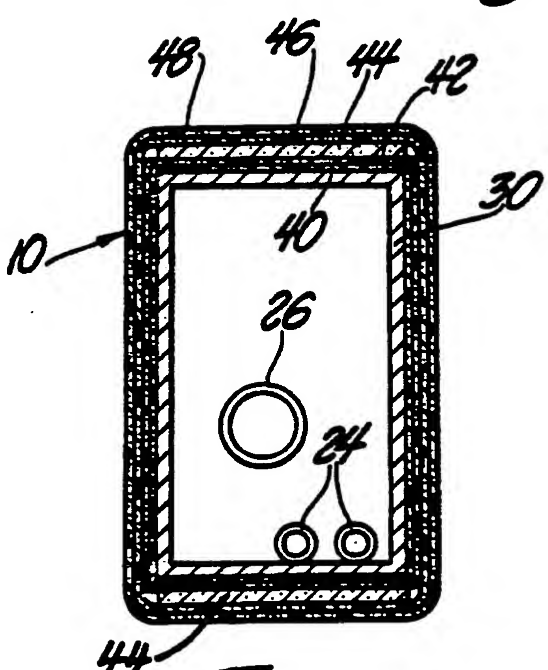

Fig.2

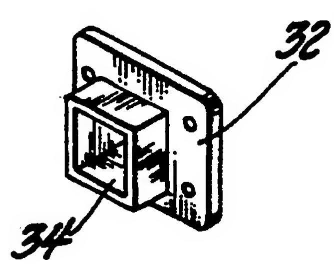

Fig.4b

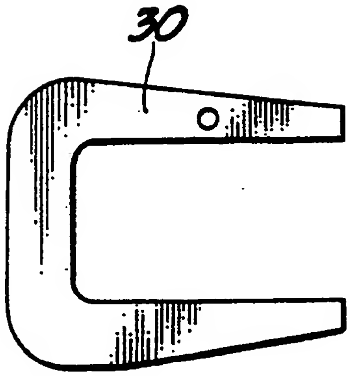

Fig. 3

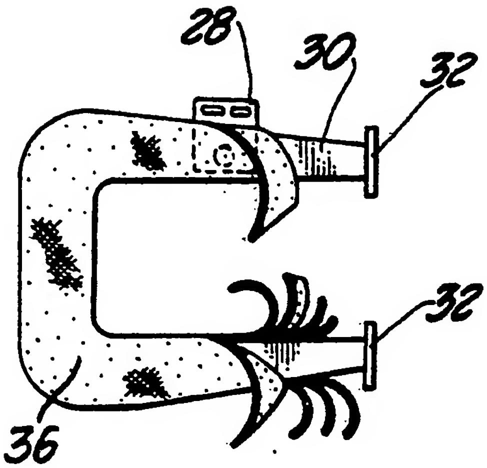

Fig. 5

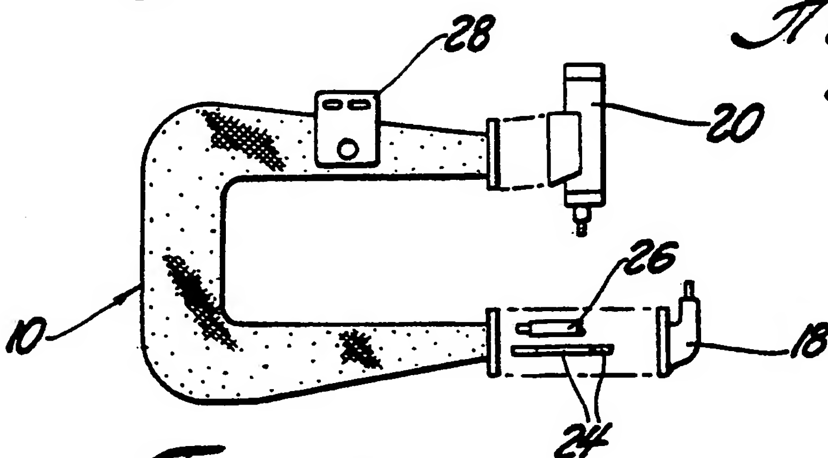

Fig. 6

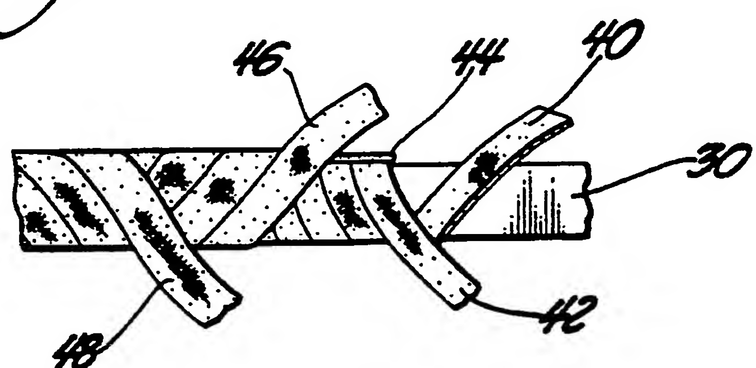

Fig. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 2734

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	WERKSTATTTECHNIK vol. 79, no. 3, March 1989, page 157, "Schweisstechnische Innovationen" * left hand column, paragraph 2, lines 5-10 *	1	B 23 K 11/28
Y	EP-A-0 113 315 (CIBA GEIGY) * page 1, first two lines, behind title *	1	
Y	DE-A-3 246 755 (R. POTT) * page 5; page 13, line 9 - page 14, line 19; figures *	1	
A	DE-A-3 420 521 ((F. KRUPP GMBH) * claim 2; figure *	1,2	
D,A	US-A-4 550 236 (T. NAKADATE et al.) * abstract; figures *	1	
D,A	US-A-3 523 172 (W.T. WILBUR) * figure 4 *	1,3	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
D,A	US-A-3 021 417 (C.C. HALBERSTADT) * figures; 1 column, lines 60-64 *	1,3	B 23 K C 08 J E 04 B F 16 L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	21-06-1990	WUNDERLICH J E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document